UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
WASHINGTON, D. C.
H. H. BENNETT, CHIEF



# ADVANCE REPORT

## on the

# SEDIMENTATION SURVEY OF GREENBELT LAKE

# GREENBELT, MARYLAND

January 27 - February 8, 1938

by

Farrell F. Barnes and Carl B. Brown


Sedimentation Studies
Division of Research
SCS-SS-33
April 1939

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## ABSTRACT

The sedimentation survey of Greenbelt Lake was made as part of a Nation-wide study of rates and causes of reservoir silting, especially as influenced by soil erosion and land use.

Greenbelt Lake, a recreational development with a surface area of 24 acres and a storage volume of 196 acre-feet when constructed in 1936, is on a minor headwater tributary of the Anacostia River 10 miles northeast of Washington, D. C. Its 530-acre drainage basin is characterized by moderately steep slopes and by soils ranging from clay loam to sandy loam developed on generally unconsolidated sands and clays of Lower Cretaceous age. The area is about 65 percent wooded, 27 percent urban (within the Greenbelt Suburban Project of the Farm Security Administration), and 8 percent idle.

During the life of the lake prior to the survey (1.6 years), severe sheet and gully erosion occurred on land that was cleared, broken up by excavation, and left exposed during the construction period of the Greenbelt project. Sheet erosion and some gullying occurred in the few abandoned fields in the drainage area, but practically no soil loss occurred in the woodland areas.

The survey revealed that deposits totaling 10 acre-feet, consisting of nearly pure silt over most of the basin but including 1 to 2 acre-feet of sandy delta deposits at the upper end, had accumulated at an average rate of 6.25 acre-feet per year. This annual rate is equivalent to more than 500 cubic feet per acre of drainage area; or, considering that the bulk of the sediment was derived from 27 percent of the drainage area within the Greenbelt development, to about 2,000 cubic feet per acre of the chief contributing area.

This investigation has demonstrated that soil losses of alarming proportions are likely to result from large-scale construction operations unless steps are taken as soon as the ground is broken to stabilize the newly disturbed or exposed soil. An indication of the success obtainable by appropriate methods is given by the results of the application of various erosion-control measures to most of the areas disturbed during the construction of the Greenbelt project. By the end of 1938, according to project engineers, washing of soil from these areas had been greatly reduced. If present cover conditions are maintained, erosion and silting should occur at only a small fraction of their former rates.

# INTRODUCTION

This report is one of a series of advance reports on reservoir-silting investigations made by the Section of Sedimentation Studies, Division of Research, Soil Conservation Service. Each reservoir survey is a part of a Nation-wide study of the condition of American reservoirs with respect to storage reduction by silting. The ultimate object of these studies is to determine rates and causes of reservoir silting in order to derive a practical index to (1) the useful-life expectancy of existing or contemplated reservoirs and (2) differences and changes in regional erosion conditions as influenced both by natural factors and by land use.

The survey of Greenbelt Lake was made during the period January 27 to February 8, 1938, by a field party consisting of L. H. Barnes, party chief; M. P. Connaughton, geologic aide; A. T. Talley, engineering aide; and two temporary assistants. Preliminary arrangements for the survey and an examination of the drainage area were made by the writers.

Acknowledgments are due Mr. Roy Braden, community manager of Greenbelt, and officials of the Farm Security Administration for their generous cooperation during this investigation. Data on the dam and a map of the drainage area were furnished by Mr. S. E. McGlathery, Jr., of the office of the Chief Engineer, Farm Security Administration, at Greenbelt.

# GENERAL INFORMATION

Location (fig. 1):

State: Maryland.

County: Prince Georges.

Distance and direction from nearest city: At Greenbelt, Md., about 10 miles northeast of Washington, D. C., and 2 miles northeast of Berwyn, Md.

Drainage and backwater: Small unnamed tributary of Indian Creek, the easternmost branch of the Anacostia River.

Ownership: United States Government. Under general supervision of the Farm Security Administration.

Purpose: Recreation.

Description of dam.

The lake is impounded by an earth-fill dam (fig. 2) with a concrete core wall, 630 feet in over-all length and 22.5 feet in height above the stream bed. The upstream face of the dam has a 2 1/2:1 slope and is paved with riprap; the downstream face, on a 2:1 slope, is protected by a dense growth of honeysuckle and grass. The crest of the dam, traversed by a sand and gravel walk about 10 feet wide, is 115.0 feet above mean sea level.[1]

The spillway, a concrete channel built into the south end of the dam, has a total crest length of about 58 feet, of which a 50-foot section, extending upstream perpendicular to the axis of the dam, is 110.0 feet above sea level, or 5 feet below the top of the fill; and an 8-foot section, connecting the upstream end of the longer part with the south abutment, has a slightly concave lip that is 109.7 feet above sea level at its lowest point. Spillway overflow is carried to the natural channel below the dam by a concrete-lined canal 14 feet wide at the top, 5 feet wide at the bottom, and 3 feet deep. The only outlet through the dam is a 24-inch cast-iron pipe 2.5 feet above the stream channel.

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[1]All elevations were established from a Soil Conservation Service third-order bench mark (elevation, 114.557 feet) on the top of the north parapet of the spillway.

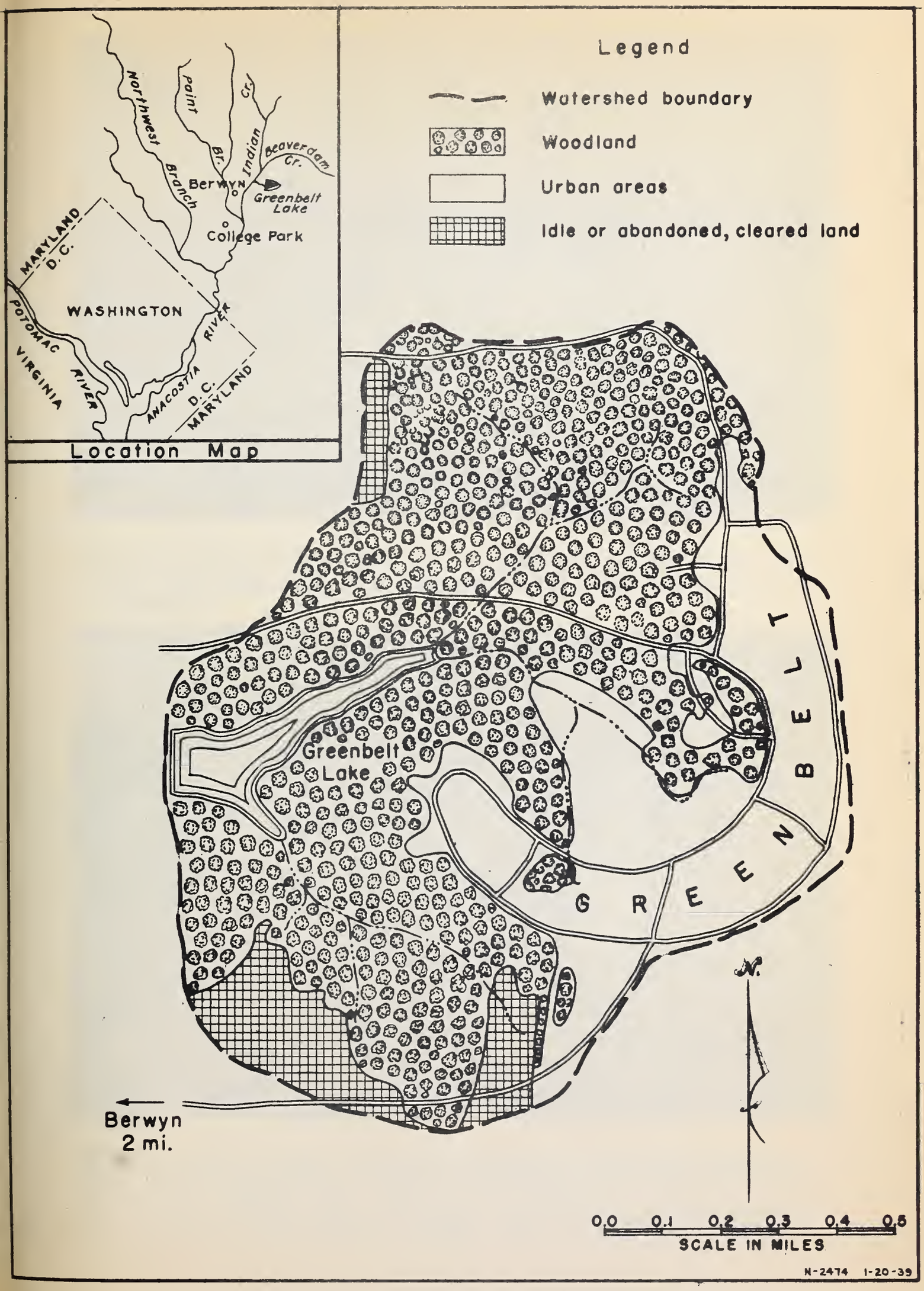


Figure 1.– Sketch map of the drainage area of Greenbelt Lake.

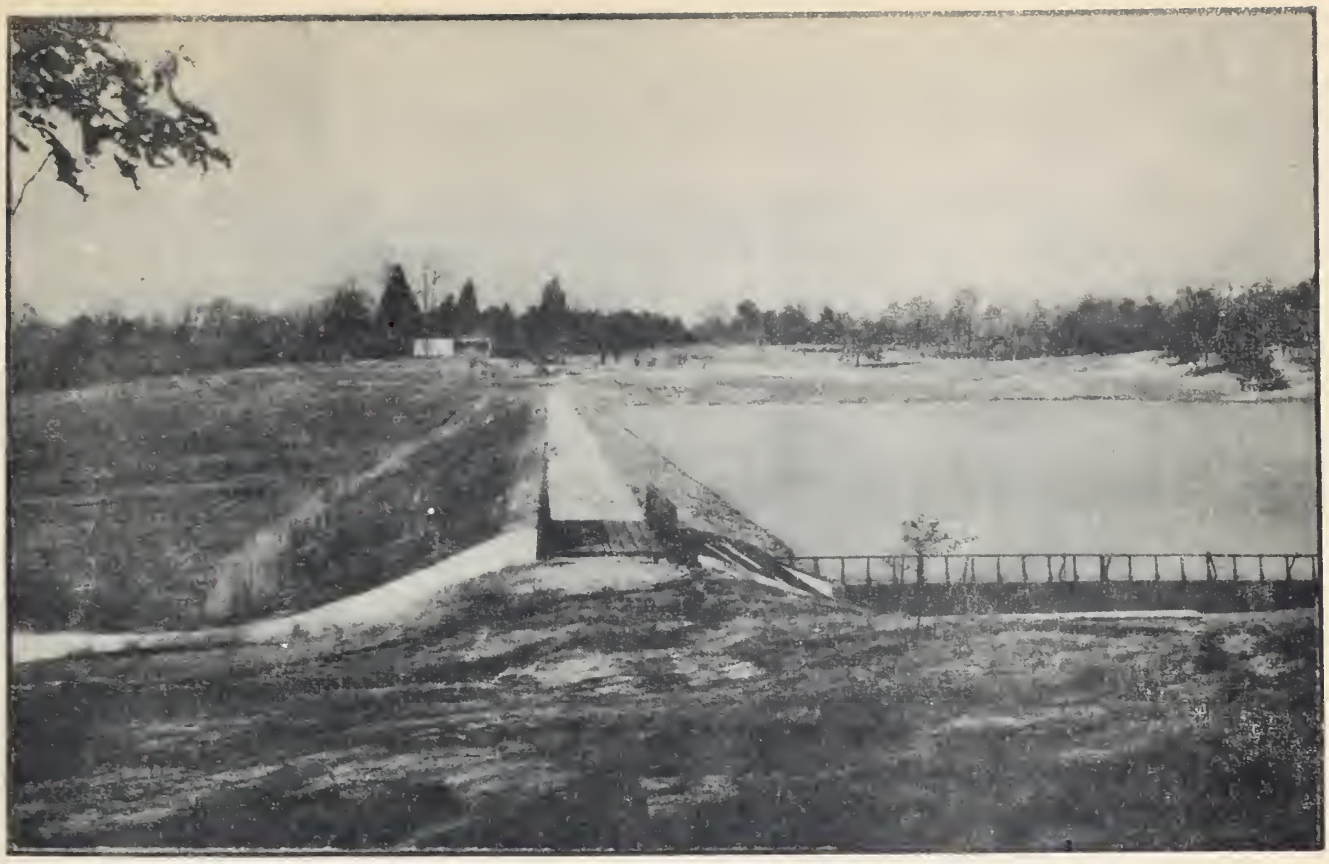

Figure 2.--View of Greenbelt Dam, showing the vine and grass covered downstream face, the riprapped water face, and part of the spillway.

Figure 3.--View of the rock-lined channel of the stream draining the town of Greenbelt. The rock pavement, although effectively preventing further down cutting of the channel, was not built far enough up the sides to prevent bank scouring by flood discharges.

Period of storage: Date storage began: July 1936. Average date of survey: February 1938. Age at date of survey: 1.6 years.

Length of lake at spillway stage: 0.44 mile (2,340 feet). Length of tributary arm: 0.12 mile (640 feet.)

| Area of lake at spillway stage: | Acres |
|---|---|
| Original | 23.7 |
| At date of survey | 23.5 |
| Reduction by silting | 0.2 |

| Storage capacity to spillway level: | Acre-feet |
|---|---|
| Original | 196 |
| At date of survey | 186 |
| Reduction by silting | 10 |

General character of lake basin.

The lake basin has a maximum width of about 550 feet near the dam, from which it narrows gradually between generally smooth shore lines to about 150 feet at the upper end (fig. 4, following p. 12). A single tributary arm, about 600 feet long and 250 feet wide at its lower end, indents the south shore line about 600 feet above the dam.

In cross section the basin is troughlike, having moderately steep sides that range from 5 to 50 percent in slope and average about 15 percent, and a relatively flat bottom averaging 200 to 250 feet in width.

The prelake channel through the reservoir area had a rather uniform gradient of about 40 feet per mile.

Area of drainage basin: 0.83 square mile, or about 530 acres, as planimetered from a blueprint of a topographic map (scale, 1/2,400; contour interval, 5 feet) prepared by engineers of the Farm Security Administration.

General character of drainage basin.

Geology.--The drainage basin of Greenbelt Lake lies at the inner edge of the Coastal Plain, and is underlain entirely by

generally unconsolidated sands and clays of Cretaceous age.[2] About two-thirds of the area, including all but the lower slopes of the main valley, is underlain by the Patapsco formation, consisting of locally indurated sands and variegated clays. The lower slopes are underlain by the Arundel formation, consisting of "lenticular masses of lignitic clays with earthy iron carbonate."[2] The Patapsco and Arundel formations are the upper and middle units, respectively, of the Potomac group of Lower Cretaceous age.

Topography and drainage.--The drainage basin, which consists merely of the uppermost branches of a minor stream system, is practically all on slopes ranging from 5 to 15 percent and averaging about 10 percent. A few small areas near the headwater divide have slopes of about 2 percent. Elevations in the drainage basin, a roughly circular area about 1 mile in diameter, range from a general average of 200 feet along the headwater divide to about 110 feet at the lake. The highest point in the area, on the divide one-half mile northeast of the dam, is about 250 feet above sea level.

Soils.[3]--The types and proportionate areas of soils in the drainage basin, as obtained from the county soil map, are as follows:

| | Percent |
|---|---|
| Tuxedo soils (undifferentiated) | 75 |
| Sassafras fine sandy loam | 14 |
| Leonardtown silt loam | 9 |
| Meadow | 2 |
| Total drainage area | 100 |

The Tuxedo soils comprise a heterogeneous group of poorly developed soils that have a surface layer ranging in color from light gray to purplish red and in texture from clay loam to sand or gravelly loam. This layer grades downward into varicolored material, ranging from sand to heavy, plastic clay, that is not a typical subsoil but rather the partly weathered parent (Patapsco) formation. "Iron crust", ferruginous sandstone, and white quartz gravel are characteristic of this formation. This type covers all the drainage area except the lower slopes of the main valley and a few small

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[2]Map of Maryland showing Geological Formations. Scale, 1/380,160. Maryland Geol. Survey, 1933.

[3]Perkins, S. O., and Bacon, S. R. Soil Survey of Prince Georges County, Maryland. U. S. Dept. Agr., Bur. Chem. and Soils, Ser. 1925, Rept. 30, 1930.

areas near the watershed divide. It is essentially coextensive with the steeper wooded slopes.

The Sassafras fine sandy loam has a surface soil consisting of dark-brownish-gray loamy fine sand in the upper 1 or 2 inches and brownish-yellow or light-brown fine sandy loam to a depth of 8 to 12 inches. The subsoil consists of friable fine sandy clay or fine sandy loam, yellowish brown to brownish red in color. This type occupies the lower slopes and the valley bottom for a short distance above the lake, and also a small area on the south rim of the drainage basin. All this soil, except in a few small cleared areas on the upland, is in woodland.

The Leonardtown silt loam has a friable grayish-yellow or pale-yellow silt loam surface soil and a crumbly brownish-yellow or light-brown silty clay subsoil. It occurs along the headwater divide in two small areas, of which the greater part lies within the Greenbelt development and the remainder is about equally divided between woods and idle land.

The soil type mapped as meadow occupies the valley bottom for about one-half mile above the dam, and is almost wholly covered by the lake.

Land use.-- The following approximate figures on land use were obtained by planimeter measurements of a map prepared from an aerial photograph of the drainage area taken in October 1936.

| | Percent |
|---|---|
| Woodland | 65 |
| Urban areas | 27 |
| Idle land | 8 |
| Total drainage area | 100 |

Most of the area mapped as woodland (fig. 1) is heavily forested with a mixture of various species of pine, oak, and gum. An area of about 80 acres in the northeastern part of the basin was cleared of all the larger trees a few years before construction of the lake and now supports a dense growth of scrub oak.

The area classed as urban includes all the land within and adjacent to the Greenbelt community proper that has been cleared of forest cover.

Areas mapped as idle land, in the northwestern and southern parts of the basin, consist of abandoned fields, which, except for

part of the area to the south, have been abandoned to rank grass, brush, and weeds during the entire life of the lake. An area of about 20 acres along the highway bordering the south rim was plowed and planted to lespedeza in 1936, but by 1939 this area had reverted to about the same condition as the adjoining abandoned fields.

Erosion conditions.--In the 1.6-year period beginning with the completion of the dam in 1936 and ending with the sedimentation survey of the lake in 1938, extremely rapid erosion occurred within the Greenbelt development, comprising about 27 percent of the total drainage area. This area was cleared of its woodland cover and a large part was broken up by excavation for buildings, roadways, sidewalks, and sewers. Extensive areas of bare soil and large dumps of loose earth were left exposed during the latter part of 1936 and all of 1937. This condition, abetted by an average slope of 10 to 15 percent, led to extremely rapid run-off and to the movement of enormous quantities of soil downstream into the lake with each rain.

Moderate sheet erosion and some gullying occurred during the same period in the abandoned fields that include about 8 percent of the drainage area, but the amount of sediment thus contributed was obviously small by comparison. The remaining 65 percent of the drainage area, being well protected by a heavy forest or brush cover, underwent practically no erosion during this period.

In the brush-covered area in the northeastern part of the basin are a few rather large gullies, which probably developed when this area was cleared of larger trees by mill operators a few years prior to 1936, but these gullies were practically healed by the end of 1938 by new vegetation and forest litter and are not believed to have contributed any appreciable amount of sediment during the period of record. A few shallow gullies have developed on the slope below a dirt road that parallels the north lake shore and are contributing a small amount of sediment to the lake.

By the end of 1938 much progress had been made in reducing excessive erosion in the Greenbelt development. All the main drainage channels had been lined with loose rock pavement (fig. 3, following p. 3), thereby greatly reducing channel erosion. Some bank scouring has occurred above the edges of the pavement, however, and at one place, about 600 feet above the head of the lake, a section of the channel that receives the discharge from most of the storm sewers in Greenbelt has been stripped of its rock lining on two occasions by the sudden floods that follow even moderate rains. This section of channel is now being repaired permanently by grouting the rock in place with cement.

Along several of the steeper grades of the highway north of the lake, the bottoms of roadside ditches have been concrete-lined. The cut banks are still exposed, however, despite attempts to establish a vegetative cover. Along the highway that skirts the south rim of the area, highway banks and ditches have been treated by the application of a heavy sod cover. Within the town proper, lawns have been established over most of the exposed surface by application of topsoil and seeding.

Two areas, one a field just south of town and the other the slope just west of the community center (fig. 5), were still exposed to excessive erosion in January 1939 but were scheduled for application of topsoil cover and sodding.

In general, therefore, erosion in this area, although extremely rapid during the construction period, which is essentially the period recorded by the sedimentation survey, is being effectively controlled in the most seriously affected areas, and consequently should proceed at a very much slower rate as soon as the projected control measures have been extended to all eroding areas and have had a chance to become effective. It will be possible to check the reduction in erosion rate by a second sedimentation survey of the lake at some future date.

Mean annual rainfall: 41.55 inches at the United States Weather Bureau station at College Park, Md., 3 miles southwest of the lake.

## METHOD OF SURVEY

The original storage capacity and the volume of sediment in Greenbelt Lake were determined by the range method of survey.[4] For horizontal control in locating ranges and mapping the shore line a triangulation system of 11 stations was expanded from a 600-foot chained base line along the crest of the dam. All elevations were obtained from the water surface, whose elevation, determined by levels from a bench mark on the spillway, remained constant during the survey. The shore line at spillway level was mapped by plane table and telescopic alidade on a scale of 1 inch to 100 feet.

Measurements of sediment thickness and water depth were made at approximately 20-foot intervals on 9 ranges, 6 across the main

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[4]Eakin, H. M. Silting of Reservoirs. U. S. Dept. Agr. Tech. Bull. 524: 25-28, 129-135, 1936.

Figure 5.--View showing gully erosion of bare slope just west of the town of Greenbelt.

Figure 6.--View of delta at the head of Greenbelt Lake.

lake and 3 across the tributary arm, that were spaced 200 to 300 feet apart (fig. 4, following p. 12). The character and thickness of the lake deposits were determined with a 6-foot silt-sampling spud. In most places the lake sediment was underlain by bluish-gray to reddish-brown sandy clay loam, the upper surface of which was commonly marked by a rootlet zone, and in places by a mat of forest litter. In certain areas from which earth was taken for construction of the dam, the underlying material was generally a mottled bluish-gray somewhat sandy clay. Underlying deposits in the stream channel consisted of compact impure medium-grained sand. At a few points the lake sediment was underlain by bog deposits, consisting of leafy matter and some sand, that had accumulated in sloughs bordering the stream channel. All these older materials were readily distinguished from lake sediment in the spud samples.

As a basis for future resurveys of the lake, all range ends were permanently marked with standard S. C. S. bronze tablets, which were stamped with the survey numbers and set in concrete bases. Resurveys to check future sedimentation can thus be made easily by resounding the same ranges.

## SEDIMENT DEPOSITS

### Character of Sediment

In the lower part of the lake the deposits consisted of rather even-textured soft reddish-brown silt and minor amounts of clay and fine- to medium-grained sand. The sediment was distinctly sandy only in the upper part of the lake, above range R13-R14 (fig. 4), and there the sand was confined largely to an elongated bar on the south side of segments 9 and 10. This bar was composed principally of brownish-gray medium- to coarse-grained clean sand, although some organic matter, mainly leaves, had accumulated in a few small interbedded lenses.

The deposits in the tributary arm were noticeably sandy throughout, but the amount and coarseness of the sand decreased downstream from the head of the arm.

### Distribution of Sediment

The deposits in Greenbelt Lake were characterized by strikingly uniform distribution over the basin as a whole, the only notable variation in thickness occurring in the delta area at the head of the main arm. The dominantly silty deposits below range R15-R16 extended over the basin floor as a uniform blanket, generally about 5 inches thick but thinning out gradually up the submerged valley slopes (fig. 7).

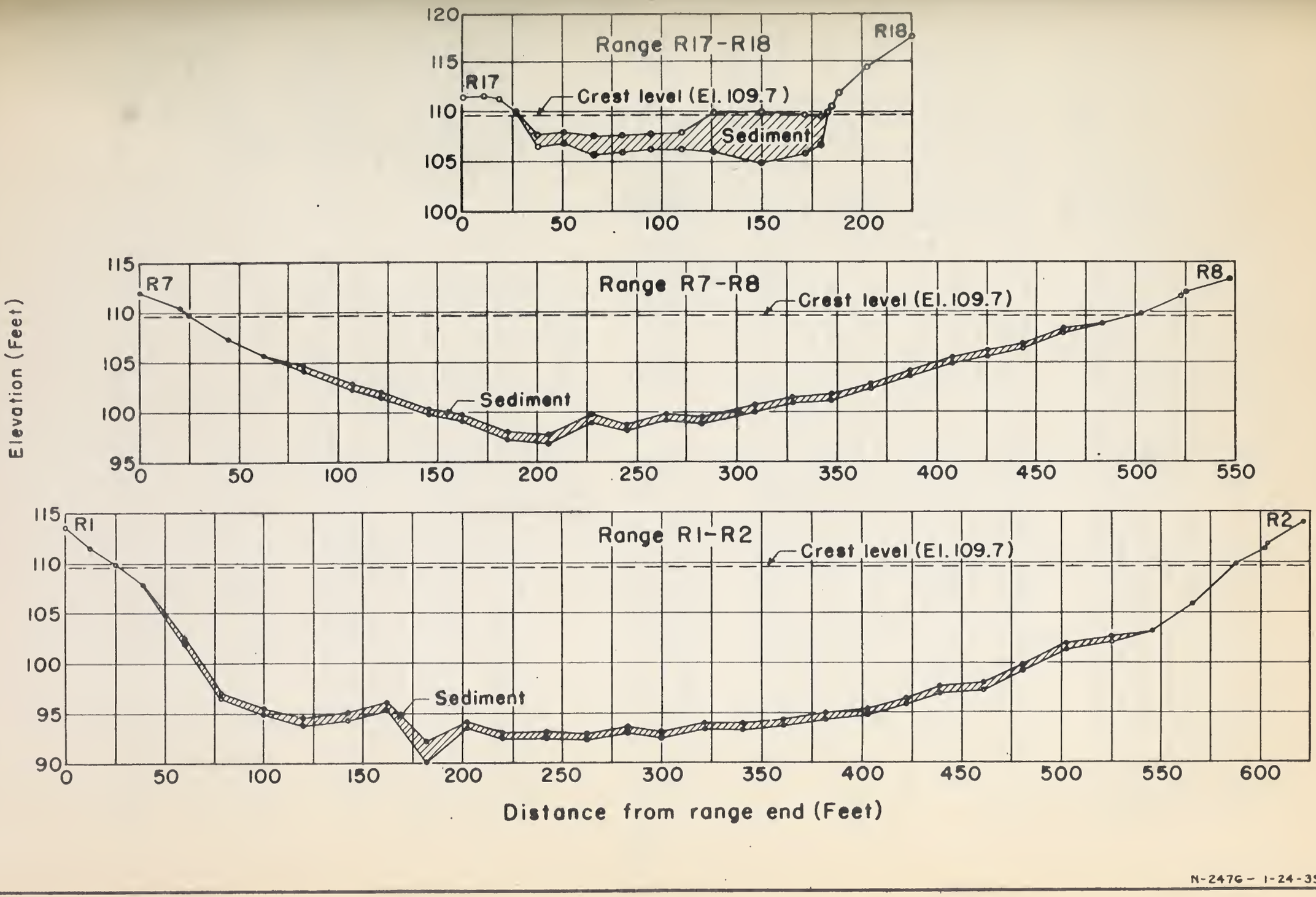



Figure 7.- Representative cross sections of Greenbelt Lake.

The average sediment thickness (computed by dividing the cross-section area of the deposit on each range by the lake width) remained almost constant between 0.3 and 0.4 foot from the dam to range R13-R14 (fig. 8), above which it increased to a maximum of 2.4 feet on range R17-R18, just below the head of backwater. The sediment attained maximum thicknesses of 5.2 feet on range R17-R18 (fig. 7), 2.1 feet on range R1-R2, just above the dam, and 1.4 feet on range R15-R16. The maximum thickness on all other ranges was less than 1 foot.

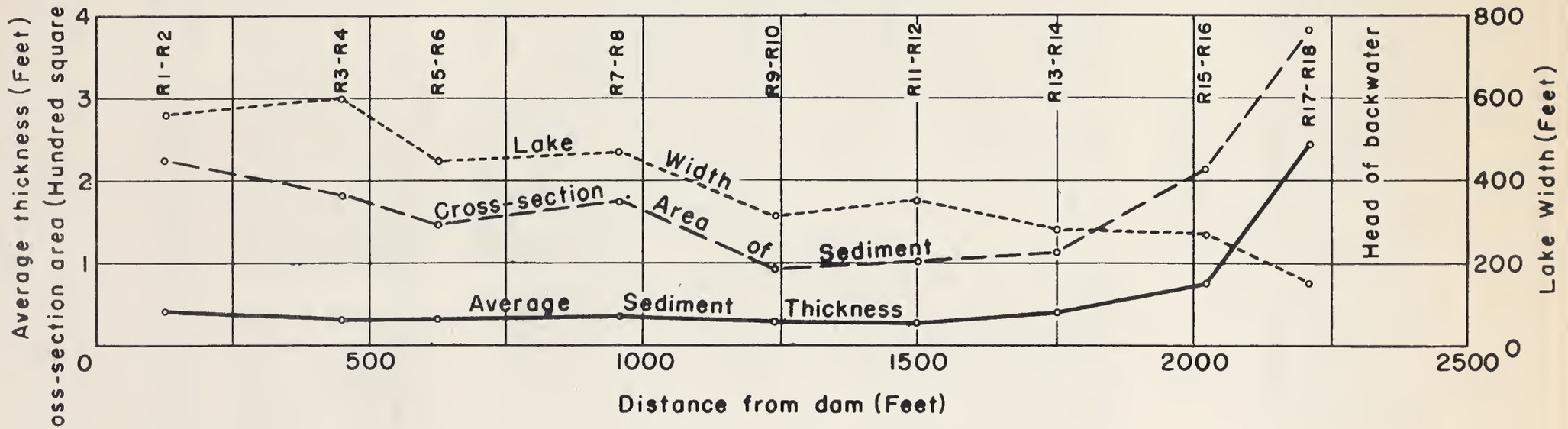
The bulk of the sand in the lake was deposited in the form of a delta (fig. 6), which had a flat upper surface a few inches above crest level and an abrupt frontal slope. This delta lies at the mouth of the southernmost of the two streams that enter the lake at its head and is the only visible evidence of excessive silting in the lake. At the time of survey it was about 250 feet long, 60 feet wide, and more than 5 feet in maximum thickness. Only a very small deltaic deposit, estimated to be 15 feet wide, 40 feet long, and 1 foot in maximum thickness, had formed at the mouth of the north feeder stream by January 1939. The contrasting size of these two deposits is a striking indication of the relative importance of the areas tributary to the two streams as sources of sediment.

The generally high turbidity of the overflow that occurs after each rain indicates that a large but undetermined fraction of the finer sediment washed into the lake is bypassed over the spillway.

## Origin of Sediment

Available evidence indicates that the bulk of the sediment in the lake at the time of survey was derived, by severe sheet and gully erosion, from areas exposed and broken up during construction of the Greenbelt project. Smaller amounts resulted from moderate sheet and gully erosion of the few cleared fields within the watershed, including the narrow cleared zone around the immediate lake shore. Some erosion has occurred on the steeper wooded slopes, particularly where roads or other construction have served to concentrate run-off, but the total amount of sediment derived from wooded areas appears to be relatively small.

Under the conditions being brought about by the application of erosion-control measures to the most seriously eroding areas, it seems certain that the rate of sedimentation, as well as the proportion of sediment derived from the developed areas, will be much less than that measured by this survey. According to project engineers, an obviously great reduction in the amount of soil being washed into the reservoir had already occurred by the end of 1938.




N-2475- 1-21-39

Figure 8.—Distribution of sediment in Greenbelt Lake.

A resurvey of the lake after an interval of several years would furnish an accurate quantitative check on the effectiveness of the erosion-control measures employed. Pending such a survey, if present cover conditions are maintained, it seems safe to predict that future rates of erosion and silting will be less than one-tenth of those prevailing during the construction period.

## CONCLUSIONS

The sedimentation survey of Greenbelt Lake revealed that, during the 1.6-year period of record, sediment accumulated at an average rate of 6.25 acre-feet per year, entailing a loss of lake volume of about 3 percent per year, or 5 percent to the date of survey. This rate is equivalent to more than 500 cubic feet of sediment per year from each acre of the entire drainage area. Inasmuch as the bulk of the sediment originated in approximately one-fourth of the drainage area, within the Greenbelt project, the actual amount of sediment derived from this area may have been closer to 2,000 cubic feet (74 cubic yards) per acre per year.

This exorbitant rate of silting is directly chargeable to the exposure, during the entire period recorded by this survey, of bare soil on most of the 150 acres of sloping land included within the Greenbelt development and in the cuts and fills of highways leading to it. It has been pointed out, however, that this condition was only temporary, and that by the end of 1938 remedial measures were almost completed. The experience of the project, nevertheless, well demonstrates the tremendous damage that can result from disturbing the natural condition of an area without provision for controlling erosion until a new protective cover or permanent artificial control can be established.

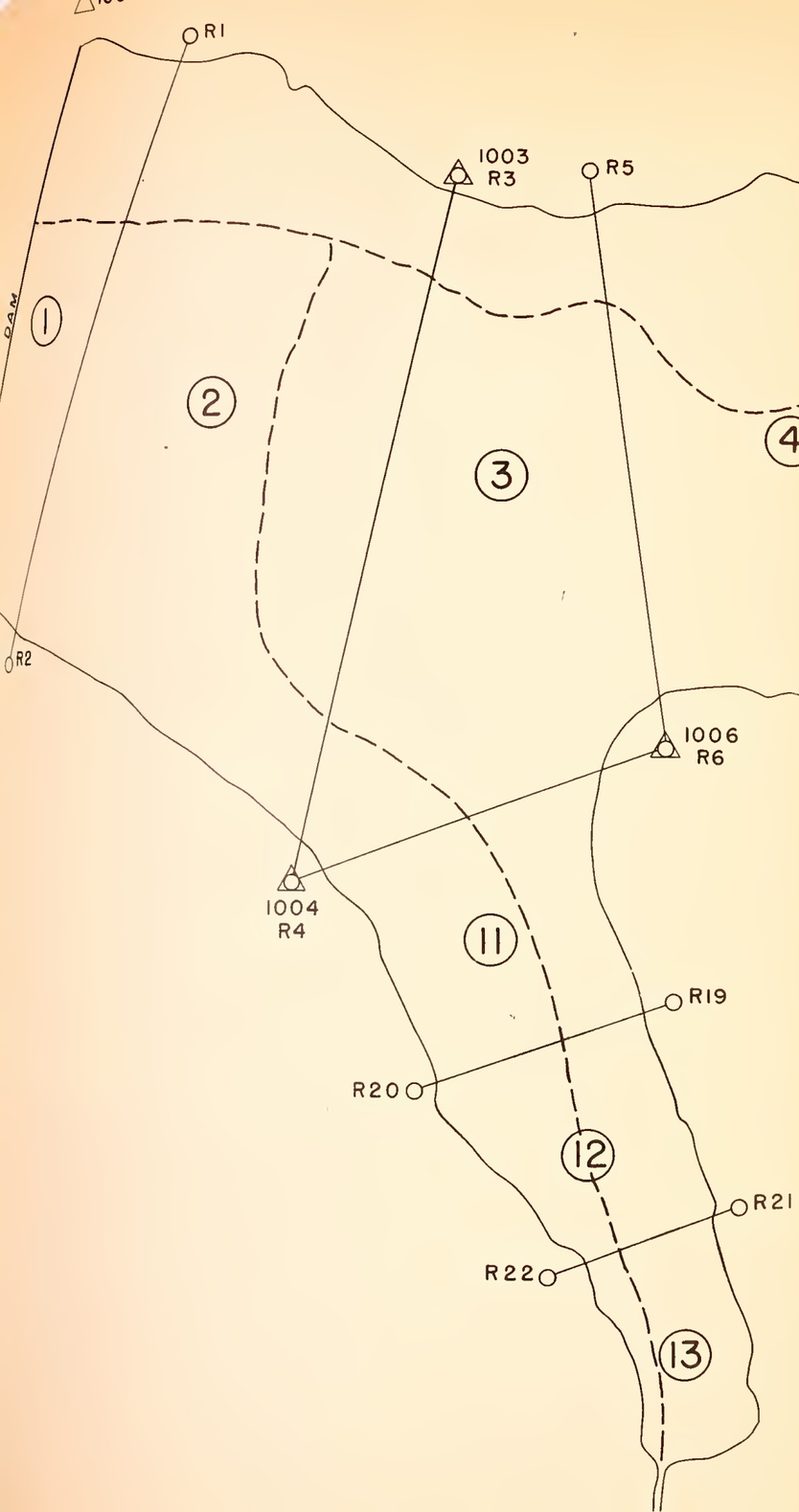
The severity of damage that may result from such exposure within a very short time is indicated by the fact that it was necessary, after a period of only 2 years, to apply new topsoil to once fertile slopes before new vegetation could be established. To this damage must be added the impairment of the lake, the useful life of which would probably be ended within two or three decades if the measured rate of silting should continue unchecked.

The quantitative results of the sedimentation survey of Greenbelt Lake are summarized in the tabulation on the following page.

Summary of data on Greenbelt Lake, Greenbelt, Md.

| | Quantity | Unit |
|---|---|---|
| Age[1] | 1.6 | Years |
| Watershed[2] | 0.83 | Sq. miles |
| | 530 | Acres |
| **Reservoir:** | | |
| Area at crest stage: | | |
| Original | 23.7 | Acres |
| At date of survey | 23.5 | Acres |
| Storage capacity to crest level: | | |
| Original | 196 | Acre-feet |
| At date of survey | 186 | Acre-feet |
| Storage per sq. miles of drainage area:[2] | | |
| Original | 236.14 | Acre-feet |
| At date of survey | 224.10 | Acre-feet |
| **Sedimentation:** | | |
| Total sediment | 10 | Acre-feet |
| Average annual accumulation: | | |
| From entire drainage area | 6.25 | Acre-feet |
| Per 100 sq. mile of drainage area[3] | 791 | Acre-feet |
| Per acre of drainage area:[3] | | |
| By volume | 538.04 | Cubic feet |
| By weight (assuming 1 cubic foot of sediment weighs 60 pounds) | 16.14 | Tons |
| **Depletion of storage:** | | |
| Loss of original capacity: | | |
| Per year | 3.19 | Percent |
| To date of survey | 5.10 | Percent |

[1]Storage began July 1936; date of this survey, February 1938.
[2]Including area of lake.
[3]Excluding area of lake.

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# GREENBELT LAKE
# GREENBELT, MARYLAND.

## SEDIMENTATION SURVEY OF FEBRUARY 1938

G.C. Dobson, Acting Head, Sedimentation Studies
Division of Research

100 0 100 200 300 400
Scale in feet

LEGEND

- Thalweg of Original Stream Channel
- 1938 Spillway Crest Line
- Area Silted Above Spillway Level
- R1 — R2 Silt Ronge
- 1001 △ Triangulotion Station
- (1) Reservoir Segment Number

Leland H. Bornes, in Chorge of Field Survey